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The Effect of Variation in Oven Temperature and Internal Temperature on Cooking Losses, Tenderness and Visual Acceptability of Pork Roasts

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To the Graduate Council:

I am submitting herewith a thesis written by Elaine Crowder entitled "The Effect of Variation in Oven Temperature and Internal Temperature on Cooking Losses, Tenderness and Visual Acceptability of Pork Roasts." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Food Science and Technology.

Bernadine Meyer, Major Professor

We have read this thesis and recommend its acceptance:

Frances A. Schofield, Nell P. Logan

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

May 25, 1965

To the Graduate Council:

I am submitting a thesis written by Elaine Crowder entitled "The Effect of Variation in Oven Temperature and Internal Temperature on Cooking Losses, Tenderness and Visual Acceptability of Pork Roasts." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Foods.

Bernadine Meyer
Major Professor

We have read this thesis
and recommend its acceptance:

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Accepted for the Council:

Dean of the Graduate School

THE EFFECT OF VARIATION IN OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON COOKING LOSSES, TENDERNESS AND VISUAL ACCEPTABILITY OF PORK ROASTS

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

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by

Elaine Crowder

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Elaine Crowder

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CHAPTER I

INTRODUCTION

For many years, it has been believed that pork to be safe for human consumption must be cooked to the well-done stage in order to destroy spores of Trichinella spiralis which are not detected by meat inspection methods. For this reason recipes for roasting fresh pork usually recommend using an oven temperature of 325° F. or 350° F. and cooking to an internal temperature of from 180° F. to 185° F. However, recent regulations concerning commercial processing of pork require that pork be heated only to 137° F. internal temperature, which has been demonstrated as satisfactory for the complete destruction of the spores of Trichinella spiralis (U. S. Department of Agriculture, 1960). In 1961, Webb, et al. recommended 149° F. as a minimum internal temperature for roasting fresh pork to allow a margin of safety. Current home practice would seem to involve excessive heat treatment. In view of the discrepancy between commercial and current home practice, it seemed desirable to test the suitability of using lower oven and/or internal temperatures for roasting pork.

Pork loin roasts from Duroc and Hampshire boars finished on the same basic ration were used in this study. The internal temperature at the center of the roasts was used as the end point for cooking. The internal temperatures tested were 149, 167 and 185° F. The first two temperatures are lower than commonly

recommended for pork cookery. The lowest internal temperature tested in this study, 149° F., corresponds to the rare stage for beef and as suggested by Webb, et al. (1961) permits a safety margin for the destruction of the Trichina organism. The 185° F. internal temperature was representative of current home practice.

Numerous studies have indicated that low cooking temperatures improve the sensory quality of beef, especially tenderness; however, few studies have been concerned with cooking pork at low temperatures. For this reason it seemed desirable to test cooking at lower oven temperatures as well as to test reduced internal temperatures. The oven temperatures employed in this study were 250, 300 and 350° F., the first two being lower than currently recommended for fresh pork and 350° F. being representative of current home practice.

Therefore, in this study, nine combinations of oven and internal temperatures were employed for roasting fresh loin of pork. The data included evaluations of tenderness by shear values, cooking losses, cooking times, visual estimates of acceptability from the standpoint of color, moistness and appearance and the per cent moisture and ether extract of the cooked roasts.

CHAPTER II

REVIEW OF LITERATURE

Numerous reports of research in the area of beef cookery at low temperatures have been published. However, very little research has been conducted involving low temperature pork cookery. Research on low temperature meat cookery in general will be reviewed in order to relate the findings of other researchers with the work done in this study.

The relationship of low temperature cookery to cooking losses, juiciness and tenderness will be discussed.

I. RELATION OF FINAL INTERNAL TEMPERATURE TO COOKING LOSSES

According to several reports, cooking losses increase as the internal temperature increases. Paul and McLean (1946) studied the effect of different internal temperatures on various veal muscles from calves of three different weights cooked in 325° F. gas ovens. The four internal temperatures used were 160, 170, 180 and 190° F. These researchers reported a continuous increase in total cooking losses with increases in internal temperature. The total cooking losses from the highest weight carcasses averaged 15.2 per cent when cooked to 160° F. internal temperature; 23.7 per cent when cooked to 170° F.; 31.5 per cent when cooked to 180° F.; and, 37.2 per cent when cooked

to 190° F. The total cooking losses from the lowest weight carcasses and the intermediate weight carcasses were less than the total cooking losses from the highest weight carcasses, but the same trend of increase in total cooking loss with increased internal temperature was found.

Visser, et al. (1960) investigated the effect of degree of doneness on the juiciness and tenderness of beef muscles cooked in ovens and in deep fat. Psoas major, adductor, rectus femoris, vastus lateralus, semimembranosus, semitendinosus and longissimus dorsi muscles were cooked in a 300° F. rotary-hearth gas oven to internal temperatures of 131, 158 and 185° F. The beef muscles were cooked in deep fat at temperatures of either 212° F. or 230° F. to internal temperatures of 113, 131, 149, 158 and 185° F. As the internal temperature increased, the total cooking losses increased except with the adductor and semimembranosus muscles deep-fat fried at 212° F. The total cooking losses of the longissimus dorsi loin roasts averaged 10.0 per cent when cooked in a 300° F. oven to 131° F. internal temperature as compared to 35.6 per cent when cooked to 185° F. at the same oven temperature. The total cooking losses of the longissimus dorsi roasts deep-fat fried at 212° F. to the internal temperature of 131° F. averaged 27.5 per cent compared to average losses of 34.7 per cent for the roasts cooked to 185° F. The roasts deep-fat fried at 230° F. to the internal temperature of 131° F. averaged 17.6 per cent total cooking losses as compared to 35.2 per cent for the roasts cooked to 185° F.

Webb, et al. (1961) used four internal heat treatments in their work with pork loin roasts. The roasts were cooked in 350° F. ovens to internal temperatures of 185, 165, 151° F. and to 151° F. maintained for one hour. Increased cooking times, dripping losses and total cooking losses with increased internal temperatures were found by these investigators. At the higher internal temperature, cooking losses totaled 29.78 per cent as compared to 15.00 per cent for the roasts cooked to 151° F. Roasts cooked to 151° F. and maintained for one hour averaged 19.98 per cent total cooking losses. However, no significant carving losses were reported due to increased internal temperature.

In 1962, Paul roasted semitendinosus muscles of beef to internal temperatures of 140° F. and 171° F. At the higher internal temperature, cooking losses totaled 26.76 per cent as compared to 13.62 per cent for the beef roasted to 140° F. As a further indication of greater cooking losses at higher internal temperatures, the per cent total moisture in beef cooked to 140° F was 68.98 per cent compared to 64.79 per cent in beef cooked to 171° F.

Weir, et al. (1962) compared broiled pork chops with braised pork chops cooked to various internal temperatures. The end-point temperatures used in braising were 185, 200, 200° F. plus seven minutes and 200° F. plus fourteen minutes. The end-point temperature used in broiling was 185° F. Greater total cooking losses were obtained when pork chops were broiled

to the internal temperature of 185° F. than when braised to 185° F. Extending the length of cooking time after the braised chops had reached 185° F. internal temperature increased the cooking losses proportionally.

II. RELATION OF COOKING TEMPERATURE TO COOKING LOSSES

In 1959, Bramblett, et al. studied paired U. S. Standard grade beef rounds. One of each pair was cooked at 145° F. for thirty hours and the other was cooked at 154° F. for eighteen hours. At the lower oven temperature the total cooking losses averaged 23.5 per cent as compared to 27.9 per cent for the paired beef rounds roasted at 154° F. The beef rounds cooked at the lower temperature and for the longer time received higher taste panel scores for appearance and texture than the meat roasted at the higher temperature and for the shorter time.

Bramblett and Vail (1964) cooked muscles from sixty paired beef rounds of U. S. Good and Standard grades to internal temperatures of 149° F. at oven temperatures of 155° F and 200° F. The beef rounds cooked at 155° F. required two to four times as long to cook. Cooking losses for the Good grade averaged 18.80 per cent when roasted at 200° F. compared to 26.01 per cent for the paired cuts roasted at 155° F. This difference was significant. There was no significant difference in cooking losses for muscles from Standard grade beef roasted at the two temperatures.

III. RELATION OF COOKING TEMPERATURE AND INTERNAL TEMPERATURE TO JUICINESS

Sanderson and Vail (1963) compared semimembranosus, semitendinosus and longissimus dorsi muscles from U. S. Good grade and longissimus dorsi from U. S. Choice grade beef, oven cooked and tube cooked to three internal temperatures 140, 158 and 176° F. Using yield of press fluid as an index to juiciness, no differences were found in the amount of press fluid between the two grades of meat. However, these researchers did find a highly significant difference in press fluid (as a per cent of cooked muscle) due to internal temperature. The press fluid averaged 54.0 per cent when the internal temperature was 140° F. compared to only 36.4 per cent at 176° F.

Weir, et al. (1963) compared left pork loin roasts cooked at 300, 325, 375 and 400° F. to paired right pork loin roasts cooked at 350° F. No significant effect on juiciness scores was caused by variation in oven temperatures. When pork loin roasts cooked to an internal temperature of 185° F. were compared to roasts cooked to 169° F., those heated to 169° F. received higher juiciness scores but lower odor scores.

IV. RELATION OF COOKING TEMPERATURE AND INTERNAL TEMPERATURE TO TENDERNESS

Cover (1943) studied the effect of extremely low rates of heat penetration on the tendering of beef. Rib and chuck roasts were cooked to the rare and well-done stages in 176° F.

and 257° F. ovens. The rare meat was heated to 136° F. to 138° F. internal temperature in the 176° F. oven. The well-done meat was obtained by heating to an internal temperature of 158° F. in the 176° F. oven and to 176° F. in the 257° F. oven. Tender roasts were always obtained when the rate of heat penetration was slow enough so that more than thirty hours were required for the meat to lose its pink color. The investigator reported that the chemical factor causing tendering in connective tissue appeared to be the hydrolysis of collagen to gelatin.

Bramblett, et al. (1959) reported that beef rounds cooked at 145° F. for thirty hours were more tender than paired rounds cooked at 154° F. for eighteen hours. The shear value for the beef rounds cooked at 145° F. averaged 12.94 pounds compared to 17.76 pounds at the higher temperature.

Machlik and Draudt (1963) heated small cylinders of Choice beef semitendinosus muscle for several hours at 1° C. intervals between 50° C. and 90° C. Minimum shear values were obtained in the range of 60° C. to 64° C. after heating thirty to sixty minutes. These authors suggested that this time and temperature range may allow for complete conversion of collagen to gelatin without the hardening of muscle fibers found with higher temperatures.

Tuomy, Lechnir and Miller (1963) tested the effects of cooking temperatures on semimembranosus muscles from beef. The meat was cut into 8-inch x 1-1/2-inch square logs and frozen. The logs were then trimmed to fit into 8-inch stainless steel tubes

7/8-inch in diameter. Thermocouples were inserted into the meat through holes in the tubes. The heating temperatures used were 140, 160, 180, 190, 200 and 210° F. over a seven-hour period. The tubes containing the meat were placed in baskets in kettles of water at temperatures 20° F. above the temperature to be investigated except that the come-up water was at 210° F. for the 200° F. and 210° F. tests. As soon as the internal temperature was the same as the desired run-temperature, the basket of tubes was transferred to a kettle of circulating water at the desired run-temperature. The tubes were removed from the water bath at different time intervals and cooled in 32° F. water. Tenderness estimates were obtained by a taste panel and with a L.E.E.-Kramer shear press. The results indicated that neither the total cooking time nor the rate of heating affected tenderness at temperatures of less than 180° F. Panel scores for meat held at 180° F. increased from 4.1 after one hour of heating to 6.1 after seven hours. Meat held at 200° F. for one hour scored 4.8 as compared to 7.3 after being heated for seven hours. Meat heated at 210° F. fell apart and could not be evaluated.

Tuomy and Lechnir (1964) studied the effect of cooking temperature and time on the tenderness of longissimus dorsi muscle of pork. The temperatures used were 140, 150, 160, 180, 190, 200 and 210° F. Procedures used in this study were similar to those of the beef study by Tuomy, Lechnir and Miller (1963). The initial heat application induced toughening which increased as the temperature increased. There was little change in tenderness with time at 140° F. At 150° F. and above, after the initial

toughening, the pork became tender to a degree dependent on both time and temperature of heating. The shear press value for the meat cooked at 180° F. was 419 pounds initially, increased to 461 pounds after one hour of heating and decreased to 323 pounds after seven hours of heating. The meat cooked at temperatures above 190° F. fell apart during cooking.

Much research has been reported concerning the effects of cooking and end-point temperatures on sensory qualities of meat; however, there are still many unanswered questions in the area of temperature relationships to sensory quality of cooked meat.

CHAPTER III

PROCEDURE

I. SOURCE OF THE MEAT

The roasts used in this study were obtained from the loins of six Duroc and three Hampshire boars finished on a basic ration by the Animal Husbandry Department of the University of Tennessee. The average age of the nine animals at slaughter was 170 days and the average weight was 230 pounds.

After slaughter the loins were removed from the animals and frozen. Prior to the beginning of this study, each frozen loin was cut into five roasts making a total of ten roasts per animal. Eighty-one of the roasts (nine per animal) were used in this study. The roasts were assigned numbers one to five beginning at the shoulder end of the loin. The frozen roasts were rewrapped in freezer paper and returned to -30^{o} F. storage until used.

II. PLAN OF STUDY

Roasts numbered two through five from the right loin and one through five from the left loin were used in this study. The cooking plan was designed to permit each heat-treatment combination to be replicated twice on roasts from each position of the loin with the exception of position one. The heat-treatments were:

Cooked at 250° F to 149, 167 and 185° F. internal temperature

Cooked at 300° F. to 149, 167 and 185° F. internal temperature

Cooked at 350° F. to 149, 167 and 185° F. internal temperature

These heat-treatment combinations were performed only once on the shoulder-end roasts from the left side. Each heat-treatment combination was replicated nine times.

Six roasts from two animals were cooked at one oven temperature each day of testing. At each test, two roasts were cooked to each of the three internal temperatures 149, 167 and 185° F.

III. COOKING PROCEDURE

The frozen roasts were weighed and placed in shallow aluminum pans using the rib bones as racks. The roasts without sufficient natural bone racks were placed on wire racks. The roasts were cooked in a revolving-hearth Despatch oven. They were heated for approximately ninety minutes before the thermometers were inserted into the approximate center of the longissimus dorsi muscle. Mercury meat thermometers were used to determine the internal temperature of the roasts. When each roast had reached the desired internal temperature, the roast was cooled at room temperature for ten minutes to determine cooking losses.

IV. DETERMINATION OF COOKING LOSSES

The weight loss due to evaporation was determined by subtracting the final weight of the pan and cooked roasts from the original weight of the pan and raw roasts. The cooked roasts were removed from the pans and the weight loss due to drippings was determined by weighing the pan and drippings and subtracting the weight of the pan. Total cooking losses were calculated by adding the evaporation and dripping losses.

V. SENSORY EVALUATIONS

Each roast was cut in half. An approximately 1/4-inch slice was then removed from the posterior half of the roast adjacent to this center cut and placed on a small plate. The remaining posterior portion of the roasts was positioned beside the slice on a tray so that the cut surface could not be seen by the judges. Three cores from the anterior half of each roast were also placed on the tray containing the slice along with the anterior portion of the roast. The trays containing the entire carved roasts were located under florescent lights for sensory evaluation.

A panel of five judges, four of whom were experienced in scoring pork, scored the meat for external appearance, color and moistness and internal appearance, color and moistness.

These sensory evaluations were attempted because it was believed that the heat-treatment combinations could produce quite

different results in the roasts. It was anticipated that the internal temperatures would affect the degree of denaturation of hemoglobin and therefore, could have an effect on the color of the lean. It was also anticipated that higher oven temperatures especially when combined with higher internal temperatures might cause excessive external browning and therefore affect external visual acceptability. Flavor evaluations were not undertaken because the nine animals used for this study were boars. Boar meat is usually considered undesirable because of its strong flavor and would not be representative of pork usually obtained from the commercial retail market.

VI. SHEAR TESTS

In this study, shear tests were used as an index to tenderness. The roasts were chilled overnight in a refrigerator to insure even temperature in all roasts when shear tests were performed using the Warner-Bratzler shear apparatus. Three cores, 1/2-inch in diameter, cut parallel to the muscle fibers, were secured from the anterior half of the roast. One core was cut from the medial portion, one from the center portion and one from the lateral portion. Each core was sheared three times and the three values averaged.

VII. PER CENT MOISTURE AND ETHER EXTRACT

All of the longissimus dorsi muscle remaining after other samples were removed from the roasts was used for determining the per

cent moisture and ether extract by a graduate student in the Animal Husbandry Department. After grinding three times triplicate, approximately two-gram samples of the finely ground muscle were dried in a vacuum oven at 95° C. to 100° C. and 20 inches of mercury for seven hours. The dried samples were then extracted with anhydrous ether in a Goldfisch apparatus. The samples were extracted for four hours. Moisture and ether extract were calculated as per cent of the cooked muscle.

VIII. ANALYSIS OF DATA

The data were grouped according to heat-treatment combinations. After obtaining treatment averages the differences among the means of the heat-treatment combinations were tested for significance using the t-distribution. Correlation of panel scores for moistness with per cent moisture was also calculated.

CHAPTER IV

RESULTS AND DISCUSSION

I. EFFECT OF OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON COOKING LOSSES OF PORK LOIN ROASTS

Data on evaporation, dripping and total cooking losses of pork loin roasts as affected by oven temperature and internal temperature are shown in Table I.

Evaporation Losses

Evaporation losses represent moisture evaporated during heating. Oven temperature had very little effect on evaporation losses. However, significant or highly significant differences in evaporation losses were obtained when internal temperatures were increased from 149° F. to 167° F. and 185° F. at each oven temperature. Average evaporation losses increased approximately 5 per cent with each increase in internal temperature. Evaporation losses averaged approximately 16 per cent when the roasts were cooked to 149° F. as compared to approximately 26 per cent when cooked to 185° F. internal temperature.

Dripping Losses

There was a tendency for the dripping losses to increase very slightly as the internal temperature increased, but in no case was the difference significant. The dripping losses at the

TABLE I

AVERAGE[a] PERCENTAGE COOKING LOSSES OF PORK LOIN ROASTS AS AFFECTED BY OVEN TEMPERATURE AND INTERNAL TEMPERATURE

Type of Loss	Oven Temperature	Internal Temperature			Difference		
		149° F.	167° F.	185° F.	167-149° F.	185-167° F.	185-149° F.
Evaporation	250° F.	13.85	19.18	25.12	5.33**	5.94**	11.27**
	300° F.	14.97	18.95	26.18	3.98**	7.23**	11.21**
	350° F.	18.63	22.13	25.95	3.50*	3.82**	7.32**
	Average	15.82	20.09	25.75			
Drippings	250° F.	5.00	5.76	5.90	0.76	0.14	0.90
	300° F.	4.64	5.36	5.72	0.72	0.36	1.08
	350° F.	5.38	5.88	6.87	0.50	0.99	1.49
	Average	5.01	5.67	6.16			
Total	250° F.	18.86	24.95	31.02	6.09**	6.07**	12.16**
	300° F.	19.60	24.30	31.90	4.70**	7.60**	12.30**
	350° F.	24.01	28.00	32.83	3.99**	4.83**	8.82**
	Average	20.82	25.75	31.92			

[a]Each figure is the average of nine values.

*Significant at P = 0.05.
**Significant at P ≤ 0.01.

highest heat-treatment combination averaged 6.87 per cent compared to 5.00 per cent dripping losses at the lowest heat-treatment combination.

Total Cooking Losses

The total cooking losses represent the sum of the evaporation and dripping losses. At the lower internal temperatures about three-fourths of the total cooking losses were due to evaporation losses while at the highest internal temperature about five-sixths of the total cooking losses were due to evaporation. Consequently total cooking losses follow the same trend as evaporation losses. The total cooking losses at the highest heat-treatment combination averaged 32.83 per cent compared to 18.86 per cent at the lowest heat-treatment combination. The increases in total cooking losses with increasing internal temperatures were highly significant at each oven temperature.

II. EFFECT OF OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON COOKING TIME OF PORK LOIN ROASTS

The cooking times of pork loin roasts as affected by oven temperature and internal temperature are shown in Table II. Cooking time seemed to be a function of both end-point temperature and cooking temperature. As the internal temperature increased, the average cooking time per pound of meat increased at each oven temperature. Cooking time of roasts decreased as the oven temperature was increased at each

TABLE II

AVERAGE COOKING TIME[a] OF PORK LOIN ROASTS AS AFFECTED BY OVEN TEMPERATURE AND INTERNAL TEMPERATURE

	Internal Temperature			Difference		
Oven Temperature	149° F.	167° F.	185° F.	167-149° F.	185-167° F.	185-149° F.
250° F.	113	138	182	25	44	69
300° F.	87	101	129	14	28	42
350° F.	74	81	91	7	10	17

[a]Minutes per pound. Each figure is the average of nine values.

internal temperature. The shortest cooking time, about one and one-fourth hours per pound, was obtained when the roasts were cooked to only 149° F. in the 350° F. oven. When roasts were cooked to the highest internal temperature, 185° F., in the slowest oven, 250° F., the cooking time was approximately three hours per pound. The roasts in this study averaged 1.9 pounds. The largest roast weighed 2.6 pounds and the smallest, 1.3 pounds. With larger roasts, cooking times per pound of meat would probably be shorter.

III. EFFECT OF OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON VISUAL ACCEPTABILITY OF INTERNAL CHARACTERISTICS OF PORK LOIN ROASTS

Average scores for internal appearance, color and moistness are shown in Table III.

Appearance and Color

Differences in the internal appearance and color of the lean of pork loin roasts cooked by the various heat-treatment combinations were slight. There appeared to be a slight preference for the roasts cooked to the two lower internal temperatures compared to roasts cooked to the highest internal temperature. However, the preference was not clear cut and no importance should probably be attached to the slight differences between the scores for appearance and color of the lean. The data were not tested for significance of the difference between these means.

TABLE III

PANEL SCORES[a] FOR VISUAL ACCEPTABILITY OF INTERNAL CHARACTERISTICS OF PORK LOIN ROASTS

Character-istic	Oven Temperature	Internal Temperature			Difference[b]		
		149° F.	167° F.	185° F.	167-149° F.	167-185° F.	149-185° F.
Appearance	250° F.	3.6	3.8	3.3	0.2	-0.5	-0.3
	300° F.	3.6	3.7	3.4	0.1	-0.3	-0.2
	350° F.	3.8	3.8	3.2	0.0	-0.6	-0.6
	Average	**3.7**	**3.8**	**3.3**			
Color	250° F.	3.4	3.5	3.2	0.1	-0.3	-0.2
	300° F.	3.3	3.7	3.1	0.4	-0.6	-0.2
	350° F.	3.6	3.7	3.2	0.1	-0.5	-0.4
	Average	**3.4**	**3.6**	**3.2**			
Moistness	250° F.	3.7	3.0	2.7	-0.7	-0.3	-1.0
	300° F.	3.9	3.2	2.8	-0.7	-0.4	-1.1
	350° F.	3.6	3.2	2.5	-0.4	-0.7	-1.1
	Average	3.7	3.1	2.7			

[a]Maximum score, 5.

[b]Negative sign indicates decrease in score with increase in internal temperature.

Moistness

Visual scores for moistness tended to decrease as the internal temperature was increased. At the lowest internal temperature, scores for moistness were slightly higher than scores for the roasts cooked to the highest internal temperature. The average moistness score of the roasts cooked to 149° F. was 3.7. On the five-point scale used this indicates that the judges considered the meat to appear moist. The average moistness score of the roasts cooked to 185° F. was 2.7 indicating that the meat appeared only slightly moist (See sample score sheet, Appendix, p. 39). The variations in oven temperature had no consistent effect on moistness scores.

IV. EFFECT OF OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON VISUAL ACCEPTABILITY OF EXTERNAL CHARACTERISTICS OF PORK LOIN ROASTS

Average scores for external appearance, color and moistness are shown in Table IV.

Appearance and Color

Again, only slight differences in appearance and color were found among roasts cooked by the different heat-treatment combinations. There seemed to be a slight preference for the appearance of the roasts cooked to the lowest internal temperature. However, the judges made no comments to explain this. Brownness of the lean and external fat was the primary characteristic

TABLE IV

PANEL SCORES[a] FOR VISUAL ACCEPTABILITY OF EXTERNAL CHARACTERISTICS OF PORK LOIN ROASTS

Characteristic	Oven Temperature	Internal Temperature			Difference[b]		
		149° F.	167° F.	185° F.	149-167° F.	167-185° F.	149-185° F.
Appearance	250° F.	3.7	3.3	3.4	-0.4	0.1	-0.3
	300° F.	3.6	3.5	3.2	-0.1	-0.3	-0.4
	350° F.	3.6	3.2	3.0	-0.4	-0.2	-0.6
	Average	**3.6**	**3.3**	**3.2**			
Color	250° F.	3.6	3.3	3.4	-0.3	0.1	-0.2
	300° F.	3.3	3.3	3.1	0.0	-0.2	-0.2
	350° F.	3.4	3.2	3.0	-0.2	-0.2	-0.4
	Average	**3.4**	**3.3**	**3.2**			
Moistness	250° F.	3.3	2.9	2.7	-0.4	-0.2	-0.6
	300° F.	3.3	2.9	2.4	-0.4	-0.5	-0.9
	350° F.	3.0	2.6	2.2	-0.4	-0.4	-0.8
	Average	3.2	2.8	2.4			

[a]Maximum score, 5.

[b]Negative sign indicates a decrease in score with increase in internal temperature.

considered in scoring external color. The judges were not consistent in their preference or rejection of roasts cooked by any of the various heat-treatment combinations.

Moistness

A slight preference was shown for the roasts cooked to the lowest internal temperature. The highest heat-treatment combination produced roasts scoring in the slightly dry range and the lowest heat-treatment combination produced roasts scoring slightly moist. Again, varying the oven temperature had no marked effect on scores for moistness.

V. EFFECT OF OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON TENDERNESS OF PORK LOIN ROASTS

Average shear values for tenderness of pork loin roasts as affected by oven temperature and internal temperature are shown in Table V. These same data are also presented graphically in Figure 1. When roasts were cooked to the lowest internal temperature, 149° F., the shear values were almost identical at all three oven temperatures indicating that the meat was apparently about equivalent in tenderness. When roasts were cooked to higher internal temperatures, response to the three oven temperatures varied. Decreasing shear values seemed to indicate that the roasts cooked at 250° F. became progressively more tender when the internal temperature was increased to 167° F. and 185° F. However, shear values for roasts cooked in 300° F. and 350° F.

TABLE V

SHEAR VALUES[a] OF PORK LOIN ROASTS AS AFFECTED BY OVEN TEMPERATURE AND INTERNAL TEMPERATURE

	Internal Temperature			Difference[b]		
Oven Temperature	149° F.	167° F.	185° F.	149-167° F.	167-185° F.	149-185° F.
250° F.	5.48	4.90	4.05	-0.58	-0.85	-1.43
300° F.	5.47	6.16	4.94	0.69	-1.22	-0.53
350° F.	5.81	6.77	5.88	0.96	-0.89	0.07

[a]Measured in pounds on one-half inch cores.

[b]Negative sign indicates decreasing shear value as the internal temperature was increased.

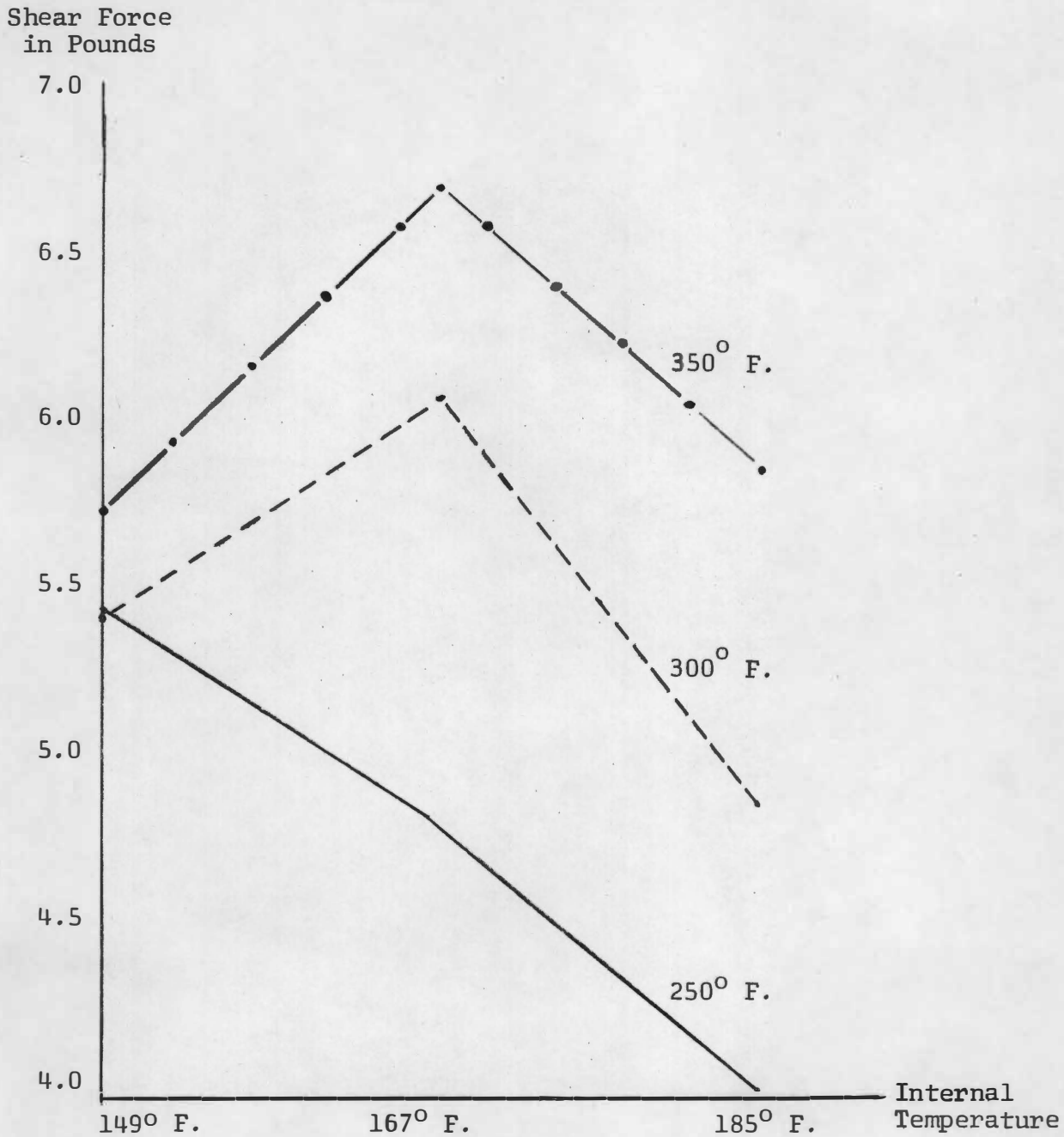

FIGURE 1

THE EFFECT OF INTERNAL TEMPERATURE ON SHEAR VALUE OF PORK LOIN ROASTS COOKED AT THREE OVEN TEMPERATURES

ovens increased when the internal temperature was increased to 167° F. This was followed by a decrease when the internal temperature was increased to 185° F. The treatment of 250° F. oven temperature combined with 185° F. internal temperature yielded the lowest shear values. Meat cooked by the heat-treatment combination of 350° F. oven temperature with 167° F. internal temperature yielded the highest shear values indicating that this meat was the least tender. A highly significant difference ($P \leq 0.01$) was found between the means of these two heat-treatment combinations. Other differences in shear values were not significant. Meat cooked at the two higher oven temperatures seemed to go through a cycle of toughening followed by tenderization as the internal temperature was increased from 149° F. to 167° F. and 185° F.

VI. EFFECT OF OVEN TEMPERATURE AND INTERNAL TEMPERATURE ON MOISTURE RETENTION AND ETHER EXTRACT OF PORK LOIN ROASTS

Per cent moisture and ether extract of pork loin roasts as affected by oven temperature and internal temperature are shown in Table VI. At each oven temperature, as the internal temperature increased the average per cent moisture decreased. Differences associated with internal temperatures were all significant except the difference between 149° F. and 167° F. at the 350° F. oven temperature. The moisture content decreased

TABLE VI

PER CENT MOISTURE AND ETHER EXTRACT[a] OF PORK LOIN ROASTS AS AFFECTED BY OVEN TEMPERATURE AND INTERNAL TEMPERATURE

	Oven Temperature	Internal Temperature			Difference		
		149° F.	167° F.	185° F.	149-167° F.	167-185° F.	149-185° F.
Moisture	250° F.	63.50	60.20	56.50	3.30*	3.70**	7.00**
	300° F.	63.63	60.74	57.80	2.89**	2.94*	5.83**
	350° F.	61.84	60.14	56.88	1.70	3.26**	4.96**
	Average	62.99	60.36	57.06			
					Difference		
					167-149° F.	185-167° F.	185-149° F.
Ether Extract	250° F.	7.24	8.45	9.98	1.21	1.53	2.74
	300° F.	7.19	7.91	8.47	0.72	0.56	1.28
	350° F.	7.83	7.69	9.55	-0.14	1.86	1.72
	Average	7.42	8.01	9.33			

[a]Average of nine values obtained in triplicate.

*Significant at P = 0.05.
**Significant at P ≤ 0.01.

approximately 3 per cent as the internal temperature increased from 149° F. to 167° F. and another 3 per cent as the internal temperature increased from 167° F. to 185° F. Little difference in moisture content was associated with differences in oven temperatures.

A correlation of 0.958 was found between panel scores for internal moistness and per cent moisture content of the cooked meat. This high correlation lends confidence in the judges' scores for internal moistness of roasts cooked by the various heat-treatment combinations.

As the internal temperature increased, the per cent ether extract tended to increase at each oven temperature. Little difference in ether extract was associated with differences in oven temperatures. The ether extract data were not tested for significance of difference between the means.

VII. DISCUSSION

Cooking Losses

The results reported in this study are in close agreement with those reported by Webb, et al. (1961). In both studies, cooking pork loin roasts to internal temperatures of 185° F. increased dripping losses and total cooking losses over those found with lower internal temperatures. When pork loin roasts were cooked to internal temperatures of 185° F., total cooking losses averaged 29.78 per cent in the study of Webb, et al. and 25.75 per cent in the present study.

The decreased cooking losses found with the lowest heat-treatment combination would increase the yield of edible meat and could be of considerable practical importance. For example, a ten-pound pork loin roast cooked at 250° F. oven temperature to 149° F. internal temperature would yield approximately eight pounds of cooked meat compared to only about seven pounds of cooked meat from a pork loin roasted at 350° F. to 185° F. internal temperature. This increased yield could be of considerable economic importance, especially in quantity food-service operations, where weighed portions are served.

Cooking Times

One possible disadvantage of low oven temperatures for roasting pork is the increased time and the possibility of increased fuel costs. Data from the present study agree with that of Bramblett and Vail (1964) who reported that beef rounds cooked at 155° F. required two to four times as long to cook as those cooked at 200° F. In the present study the shortest time, 74 minutes per pound, was obtained with the combination of 350° F. oven temperature and 149° F. internal temperature. The longest cooking time, 182 minutes per pound, was obtained with the combination of 250° F. oven temperature and 185° F. internal temperature. Measurements of fuel consumption would be necessary to evaluate the economic importance of these differences.

Sensory Tests

Differences in both the external and internal appearance and color of pork loin roasts cooked by different heat-treatment combinations were slight. It is interesting that none of the heat-treatment combinations produced roasts scoring in the very desirable range. This may have been due to the fact that the cooked roasts were held overnight in a refrigerator prior to scoring. Therefore, the external fat appeared dull and brittle rather than oily and greenish pigments had developed in the lean of many of the roasts. It seems worthy of note that none of the roasts were scored as being undesirable in the characteristics judged in this study.

The results of the panel scores for moistness and moisture retention determinations are in agreement with those of Weir, et al. (1963). As the internal temperature increased, the per cent moisture decreased and panel scores for moistness decreased slightly.

Further work on temperature relationships in cooking pork roasts should include panel judgments of tenderness and flavor.

Shear Tests

No explanation for the lower shear values obtained with the 250° F. oven can be made on the basis of the data obtained in this study. It could be hypothesized that this slower rate of cooking permitted more conversion of collagen to gelatin, resulting in more tenderization. Chemical measurements of collagen changes would be necessary to test this hypothesis.

CHAPTER V

SUMMARY

I. SCOPE OF THE STUDY

The purpose of this study was to determine the effects of variations in oven temperature and internal temperature on the cooking losses, cooking times, visual acceptability, tenderness and moisture content of pork loin roasts. Nine roasts were obtained from the loins of six Duroc and three Hampshire boars, making a total of eighty-one roasts tested in this study.

Nine heat-treatment combinations were used. Each treatment was replicated nine times. For each test, except the last, six roasts from two animals were cooked at either 250, 300 or 350° F. oven temperature. Two roasts were cooked to each of the three internal temperatures: 149, 167 and 185° F. For the last test only three roasts were cooked. The roasts were cooked in a revolving-hearth Despatch oven.

II. PRINCIPAL FINDINGS

Only slight differences in cooking losses were associated with oven temperature, but significant increases in evaporation and total cooking losses occurred as the internal temperature was increased from 149° F. to 167° F and 185° F.

The roasts cooked at 350° F. to 149° F. internal temperature required the shortest cooking time. Cooking times at 250° F. were

about one and one-half to two times longer than at 350° F.

Panel scores for external and internal appearance and color of roasts cooked by the different heat-treatment combinations showed no definite preference for the roasts cooked by any combination. Visual scores for moistness tended to decrease as the internal temperature was increased. A high correlation was found between panel scores for moistness of the lean and per cent moisture content of the cooked meat.

Slight differences in shear values were associated with both oven temperature and final internal temperature. When cooked at 250° F., the shear values decreased slightly as the internal temperature increased. When cooked at 300° F. or 350° F. shear values increased when the final internal temperature was increased from 149° F. to 167° F. and then decreased when the end-point temperature was 185° F. The lowest shear values were obtained when roasts were cooked at 250° F. to 185° F. internal temperature. The highest shear values were obtained when roasts were cooked at 350° F. to 167° F. internal temperature. The difference between these was highly significant.

III. CONCLUSIONS

Additional work would be necessary before drawing any conclusions as to the best temperature combinations for roasting pork loins. Measurements of fuel consumption would be necessary to evaluate the economics of using the varying temperature combinations.

Additional sensory evaluations should include panel estimates of flavor and tenderness.

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APPENDIX

ROAST PORK

Visual Acceptability Score Sheet

Judge_____ Date_____

Directions: Score appearance, color and moistness using the scales indicated below. Do not use fractional points.

Color and Appearance:
- 5 Very desirable
- 4 Desirable
- 3 Acceptable
- 2 Slightly undesirable
- 1 Undesirable

Moistness:
- 5 Very moist
- 4 Moist
- 3 Slightly moist
- 2 Slightly dry
- 1 Dry

Sample Number	External			Internal		
	Appearance	Color	Moistness	Appearance	Color	Moistness

Please describe color of roasts and make any other comments.

Sample Number	